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The Results of Integration of the North Star Microcomputers into the Remote Sensing Branch's Data Processing System

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Abstract

This report describes the integration of the North Star microcomputers into the Remote Sensing Branch's data processing system. The report points out the improved and expanded service obtained by using the microcomputer to control shared printing devices. It also documents the reduction in network charges resulting from converting an input/output intensive task from central processing on a time sharing system to local processing on microcomputer systems.

Acknowledgments

The author would like to express his gratitude to Martin Ozga, Walt Donovan and Gary Angelici for their invaluable programming skills and knowledge.

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SUMMARY

This report discusses the integration of microcomputers into the Statistical Reporting Service's remote sensing processing system. The report describes two uses of a North Star microcomputer. First, the report discusses the use of the microcomputer as a dedicated device driver controlling a local printer. The use of the device driver gave SRS personnel control of the printer communications at both the host computer and the printer. This control enabled SRS personnel to improve printing speed through encoding data. Control at the printer end of the communications also allowed two host computers to share the same printer without human intervention. Secondly, a highly interactive process (segment digitization) was transferred from a time sharing system to a local microcomputer. The highly interactive nature of segment digitization was idealy suited for a local microcomputer system. The one year savings obtained from reduced communication costs nearly offset the cost of the microcomputer equipment purchased.

INTRODUCTION

The Remote Sensing Branch (RSB) uses Landsat data for improving crop acreage estimates. The large volume of data involved in this process requires relatively efficient automated processing techniques. RSB processing requirements span the realm from highly computational tasks to highly interactive tasks that are input-- and output--intensive. Appendix A shows how RSB's system tries to match processing need with facility capabilities.

Part of setting up the current processing structure involved selecting a microcomputer to:

1) Act as a communications handler to allow our DEC PDP 11/44 and BBN's DEC 10 to share a printing device in an efficient manner.

2) Be used for segment digitization (see page 7) to reduce the demand for costly network communications.

Since the nature of both tasks were highly specialized, it was necessary to design the system and develop specialized software for both tasks.

This report discusses the integration of the North Star microcomputers into RSB's overall processing system. The report covers the philosophy behind their use and the results of the integration.

CHOICE OF A MICROCOMPUTER

The North Star Horizon (see Appendix B) microcomputer was chosen by the Remote Sensing Branch for two reasons. First, the U.S. Department of Agriculture has used North Stars for a number of years. Most of this use has been in underdeveloped countries where environmental conditions are sometimes harsh and repair services limited. Under these demanding situations the North Star has proved to be reliable. Secondly, the North Star Horizon is based on an S-100 bus design. At the time of development we were uncertain about interface requirements and felt that the S-100 bus design would provide access to more interfacing and system expansion equipment.

THE MICROCOMPUTER AS A DEVICE DRIVER

Philosophy

Prior to the use of microcomputers, RSB's in-house processing system consisted of a dedicated telephone line to BBN (Bolt, Beranek and Newman, a DEC 10--Tenex system) in Boston. This line was connected, through a multiplexor, to two digitizing stations, a

Trilog color printer and a Houston Instruments Complot plotter. The digitizing stations and the plotter communicated with BBN at 300 bits per second (bps) while the printer communicated at 1200 bps. This configuration (Figure 1) worked fine at first, however, as our processing load increased shortcomings in the system became apparent. At certain stages in our processing, it was necessary to generate large specialized prints (see figures 3 and 4) for reviewing the registration of ground data to Landsat digital data [1]. At these stages, a backlog of jobs waiting for access to the printer would develop. Although the Trilog line printer could print 250 lines per minute, the volume of data being transmitted from BBN kept us from running the printer anywhere near capacity. To further complicate matters, future plans called for purchasing a DEC PDP 11/44 that would require direct access to the same printer. To improve printing speed as well as allow the PDP access, RSB decided to run the communication lines from BBN and the PDP to the printer through a North Star microcomputer. By using the microcomputer as a device driver we could control the communications at both the transmission and receiving ends. This allowed us to do the following:

1) Program the print driver at BBN to code the data prior to transmission. On receipt of the data the North Star would decode it and send it to the printer. This process would reduce the amount of data being transmitted from BBN and improve our printing speed.

2) Use the North Star as a switch to allow both BBN and the PDP to access the printer without human intervention.

Implementation

The installation of the North Star as a device driver was a gradual process. The work spanned two calendar years and involved about three man months of programming time. The first step in the installation was to set up the hardware and design software to receive and print data directly from BBN without any coding. Figure 2 shows the first stage system configuration. The two digitizing stations and the plotter remained at 300 bps. BBN and the North Star communicated at 1200 bps. Three key issues influenced the design of the software:

1) The main objective was to increase printing speed.

2) The data received from BBN would arrive at the North Star in a sporadic manner. Therefore, to avoid the loss of data, the microcomputer had to be ready to handle incoming data from BBN at any time.

3) The software had to be designed to allow for future expansion. Although at the time we were trying to receive data and print it as received, we did plan to expand the system to allow us to receive coded data, decode it and then print it.

The first two issues dictated that at least part of the software would have to be written in assembler code and that the design should include the use of interrupt driven routines to handle data from BBN. The software design that evolved consists of three main modules. One module was written to allow the North Star operator to communicate with BBN and the North Star. This allows the operator to make sure that the North Star and BBN were communicating and start the print driver programs. The second module handles all the communication with BBN. It receives data and stores it in one of three memory areas (buffers) in the North Star. The last module handles all the processing necessary for printing. These three modules communicate with each other through a shared area of memory.

The first module (DLASMB) is simply a data transfer routine. It takes data received from BBN and sends it to the console terminal or takes data received from the terminal and sends it to BBN. This transparent link between BBN and the operator continues until the operator types a control-P signaling the North Star to get ready to receive print files. At this point, some preliminary information is received by the North Star such as the file name and print file type (see Appendix C). The program control then shifts to the printing routine. Upon initial entry into the print routine no data is available from BBN so the print routine waits for the receiving module (BFASMB) to fill up one of the three available data buffers.

The receiving module is a port handler that initiates when a character is received at the North Star port connected to BBN. To be able to do this we first hard-wired the North Star to enable interrupts off of the BBN serial port. This sets up the system so that when a character is received at the port the processor is alerted and it suspends the current program. The processor then starts executing the program loaded in a specific memory location. This location is determined by the interrupt wiring configuration. In our application, the program loaded in this part of memory is simply a jump to the BFASMB program so that when a character is received at the BBN port the processor executes BFASMB. After storing the incoming character, the processor returns to the print program at the point where it was suspended. In this manner, we guarantee that the processor will be able to handle data from BBN immediately when it arrives but it does not waste time waiting for characters. BFASMB not only receives the data from BBN, it handles all the communication protocols. Upon filling one of the three buffers BFASMB tells the print routine, through the shared parameters, which buffer is ready. It then checks to see if the next buffer is free and signals the BBN driver to start sending the next buffer.

The initial print routine written (STRASMB) is very simple. It first checks for available data in one of the buffers then reads the data and sends it to the Trilog printer. It then checks for data in the next buffer and continues until the printing is complete.

After the initial system was up and running we quickly devoted time to improving printing speed. Because of the structure of the software system we were able to handle specialized printing by developing new print modules with no changes to DLASMB or BFASMB. The modules developed were MODASMB, GSASMB, and PLTASMB.

MODASMB is a print module for listing files with control characters such as program source files. This routine is essentially like STRASMB except that the routine examines the data for either a tab or a special ASCII control character. The routine expands tabs to eight spaces and each control character (except carriage return, line feed and form feed) is printed as an " character". Therefore, control-A shows on the printout as " A". Again, this routine is relatively simple and with the exception of saving the transmission of spaces due to the use of tabs, it does little to improve printing speed.

GSASMB handles print files which we call greyscales (Figure 3). Greyscale files were one of the two file types that had been causing a backlog on the printer. As shown in Figure 3 the greyscale consists of a file header, the file body, and a footer. The body of the file consists of a line number followed by a line of special characters, then the line number repeated. Although there are eighteen of the special characters available as a special option on our Trilog, we felt that no more than fifteen were needed in any one greyscale. Because of this, we were able to derive a relatively simple coding scheme to reduce the number of characters that had to be sent from BBN. The following is an outline of the coding scheme used.

1) BBN sends the number of special characters to be used in the greyscale (1 to 15).

2) The actual character codes to be printed are sent in sequential order (ie. 1 is first, 2 is second, etc.).

3) The file header is then transmitted directly and GSASMB simply reads the characters and sends them to the printer.

4) After the header is sent, BBN transmits a special character telling the North Star that the file body follows. This character is followed by the initial line number, the number of characters per line, and the number of lines in the body of the file.

5) The body of the file is transmitted in coded form. Two character indicators are coded into each byte transmitted. The lower four bits indicate the first character, the high order four bits indicate the second character. The four bit indicator is used as a pointer to the character code received in part (2) above. Therefore, the bit pattern 0001 indicates that the first character received in part (2) should be printed. GSASAMB decodes the data, generates the appropriate line numbers and characters for each line, and prints the line.

6) After the body of the file is complete BBN transmits the footer uncoded. GSASMB reads the footer and sends it to the printer.

PLTASMB is the routine that handles plot files. Plot files are data files which, when printed using the dot printing capabilities of the Trilog, generate line drawings. Figure 4 shows a typical plot. To generate a plot on the Trilog printer, one must first send to the Trilog a control character to put the printer in plot mode for the current line. Afterwards, the printer accepts eight bit bytes using the low order six bits to determine the print no-print sequence of dots. For example, when in plot mode, if the Trilog receives the byte 01110011 the printed pattern of dots would be print, print, no-print, no-print, print, print . The Trilog remains in plot mode until the end of the current line. In viewing Figure 4, one can see that it takes a considerable number of characters to generate one plot line. One can also see that in a typical RSB plot each plot line usually contains long sequences of no-prints. The following coding scheme was implemented to reduce the amount of data transmitted from BBN to the North Star in order to print a plot file.

1) As with GSASMB the file header is transmitted directly as printed.

2) For the body of the file BBN transmits a special character indicating that the following data are a coded plot line. The next byte gives the number of dots to print followed by a byte giving the number of no-prints, etc. until a special character is received indicating the end of the plot line. This sequence is repeated for each plot line in the body of the file.

3) After the body of the file is completed the footer is printed directly. The backward form feed option on our Trilog allows the field labels shown in Figure 4 to be transmitted as part of the file footer.

In June 1982, RSB installed a PDP 11/44 and a Codex 6010 Statistical Multiplexor. The installation of the multiplexor allowed us to increase the baud rate of the line from BBN to the North Star-Trilog to 2400 bps. Shortly after the PDP was installed, we modified the design of our system to give it direct access to the North Star. To do this we first rewired the North Star to allow for interrupts from BBN or the PDP ports. The wiring was done so that each port interrupt forced the processor to jump to a different memory location. After the North Star was rewired the only thing left to do was to write a few small routines to handle the interrupts from the inactive host when the other host was printing. Since the system could tell which port sent the data by what place in memory the interrupts jumped to, the logic of switching from BBN to the PDP turned out to be relatively simple. If the printer is idle and either host requested access, the North Star would respond. However, if the printer is printing from one of the systems and the other requested access, the North Star would not respond but would remember that the other host made the request. After the North Star completed printing the current file, it would return to the waiting host and give it access to the printer. In this manner, if both systems were backlogged, the printer would cycle back and forth between BBN and the PDP. Figure 5 shows the current system configuration with the PDP connected to the North Star over a direct line at 9600 bps and BBN connected through a dedicated port on the multiplexor at 2400 bps.

Results

The North Star Trilog has been operating eight hours a day five days a week since November 1980. Except for the loss of two memory chips (2K), we have had no hardware problems. The system software has proven to be just as reliable. The software has required almost no modifications since the system upgrade in 1982. The use of the North Star as a device driver has been very successful. Under the present configuration, RSB can print greyscale files over twice as fast (2.3 times as fast on the average) using GSASMB as can be done without the coding scheme. PLTASMB can plot typical RSB plot files over three times faster than without the North Star setup. The one criticism of the system might be that the present North Star connected to the Trilog is more hardware than necessary. We could have obtained the same results with one disk drive and about half the memory presently available.

THE MICROCOMPUTER AS A DIGITIZING WORK STATION

Philosophy

In addition to the LANDSAT processing done by RSB personnel in Washington, D.C. the remote sensing program is designed so that some data preparation work is performed by personnel in four State Statistical Offices (SSOs). A large portion of the data preparation work done by the SSO's is referred to as segment digitization. This is the process by which field boundaries drawn on aerial photographs are recorded in computer compatible form. The digitization is done by utilizing an Altek digitizing tablet controlled by the Editor software system at BBN. The paper by Donovan and Ozga [2] describes the Editor digitizing software. Figure 6 shows the original hardware configuration in each SSO. In order for the SSO's to run the software at BBN, it was necessary for them to have access to the TELENET telecommunications network. Using this network, each SSO connected to BBN and used the EDITOR software in an interactive mode. Because the digitization process is highly input/output (I/O) intensive the major expense of the process was the network and computer connect times. This condition presented an ideal situation for using the North Star microcomputer. Our goal was to move the digitization software to a North Star microcomputer, use the microcomputer to control digitization, and save the completed work on a disk file. The data would then be transferred to BBN over the TELENET network. We hoped that this would significantly reduce our network costs.

Implementation

In the spring of 1982, Walt Donovan from Technicolor Government Services completed the conversion of the EDITOR digitization software from BBN to the North Star and Osborne microcomputers. A North Star microcomputer was installed in the Missouri SSO and an Osborne in the Iowa SSO. After a month's use, the Osborne microcomputer developed problems with the optional 12 inch monitor and segment digitization for Iowa was completed under the old BBN method. In Missouri, however, the North Star performed admirably and despite minor software problems, the Missouri personnel were able to complete the 1982 digitization using the microcomputer. Table 2 shows a comparison of the TELENET connect times for the Missouri SSO (using the microcomputer) and the Oklahoma SSO which did approximately the same amount of digitization over the network. It must be pointed out that both Missouri and Oklahoma maintained a plotter connected to BBN over the same TELENET network. We believe it is reasonable to assume that the plotter accounts for about half of Oklahoma's total connect time. Therefore, it appears that the use of the North Star saved 200 to 300 hours of connect time for Missouri. Because of the successful test in Missouri, RSB installed North

Star microcomputers in the three remaining states (Iowa, Oklahoma and Kansas). The microcomputers were used in all four states for the 1983 project. Figure 7 shows a general diagram of the current North Star digitizing station. Actual hardware configuration differs slightly for the systems in Iowa and Kansas because of older model digitizing tablets.

Results

It is hard to determine the results for the 1983 implementation. Although the North Stars performed up to expectations the existing digitizing and plotting equipment presented numerous problems. Despite these equipment problems Missouri, Iowa and Kansas were able to do nearly all of their digitizing on the microcomputers whereas Oklahoma was forced into returning to the old BBN method. Table 3 shows the number of segments digitized and the TELENET connect times for the four states. The connect times shown in Table 3 still include the connect time for plotters in each state. Although comparable data are not available, review of Tables 2 and 3 support our belief that use of the microcomputer is saving over 200 hours per year per state in connect charges. At the current rate of about $24.00 per hour it is apparent that the North Star system can just about pay for itself in the first year's savings. (See Appendix D for North Star equipment costs).

Table 1: Number of Segments Digitized, Network

Connect Times and Number of Packets Transmitted - 1982

State	Number Segments	Number Packets	Connect Time (hrs)
Missouri	380	948,438	313
Oklahoma	250	695,656	664

Table 2: Number of Segments Digitized and

Network Connect Times - 1983

State	Number Segments	Connect Time (hrs)
Missouri	450	209
Oklahoma	180	401
Iowa	280	158
Kansas	390	199

Although use of the North Star has reduced connect times on the Telenet network there are some problems with using the microcomputer. First the personel involved needed to be trained to use the computer. Although there is little difference between using the BBN segment digitization program and the North Star version, personel needed time to adjust to the new computer system. Secondly, the current file transferring capabilities are very primitive. Because of this transferring files from the North Star to BBN can be tedious. Lastly, although the North Stars have proven to be reliable we still must consider the potential for system failure, the availability of maintenance and the potential impact on the remote sensing project.

Future Work

As has already been mentioned, current communication costs include connect charges for a plotter located in each SSO. The primary function of these plotters is to create line plots of the digitization work. Since all of the digitization is being done on the North Star microcomputers, the next logical step would be to also control the plotters from the North Stars. Gary Angelici of Technicolor Government Services completed the conversion of the BBN plotting routines to the North Star during 1983. RSB personnel plan to utilize these routines during the 1984 project. Therefore the SSO's will only use the TELENET network for file transfer, reducing our network costs to the bare minimum.

Conclusions

The integration of microcomputers into SRS's remote sensing processing system has been very successful. The microcomputer being used as a device driver has been in operation daily since installation with little or no problems. Although the equipment used has more capabilities than necessary, it did allow us the flexibility of customizing a device driver to meet our specialized needs. The transfer of segment digitization to a local microcomputer is a prime example of the use of these single user systems. The placement of these microcomputers in our SSO's not only is saving SRS about $4,000 per year in connect charges per system, it has spurred the development of other applications for in-house systems.

Recommendations

This report summarizes two uses of a microcomputer. The first use improves the productivity of our current system. The second is an example of how local microcomputers can be used to reduce processing costs. It is the recommendation of this author that work be continued to improve productivity and possibly reduce cost through the use of localized processing both in remote sensing and other agency functions.

References

1. Gleason, Chapman, Robert R. Starbuck, Richard Sigman, George A. Hanuschak, Michael E. Craig, Paul W. Cook, and Richard D. Allen. "The Auxiliary Use of Landsat Data in Estimating Crop Acreages: Results of the 1975 Illinois Crop-Acreage Experiment" U.S. Department of Agriculture, Statistical Reporting Service, SRS-21, October 1977, page 12.

2. Ozga, Martin, Walter E. Donovan, Chapman Gleason. "An Interactive System for Agricultural Acreage Estimates Using Landsat Data". Fourth Symposium on Machine Processing of Remotely Sensed Data, June 1977.

Appendix A

RSB's Processing Need, Description and System Used

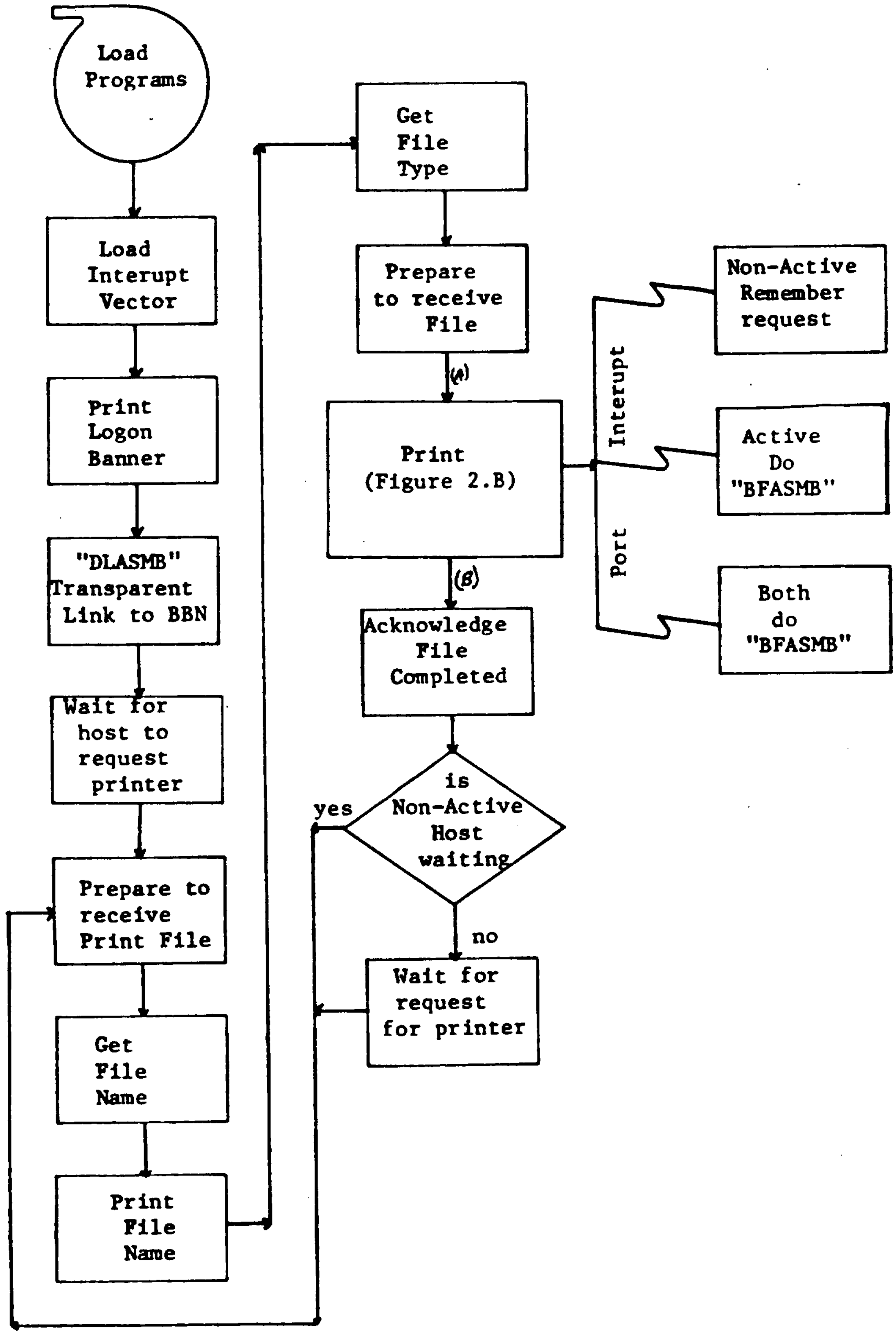
Processing Need	Description	Facility/Location	System
Ground Data Edit	Batch Editing and reformating of existing survey data	Martin Marietta Systems Orlando, Florida	IBM 3081
Video Digitization	Image recording and editing of polygon tracings	In-house Washington, D.C.	PDP 11/44
Manual Digitization	Interactive digitizing of field boundary data	Field Offices MO, KS, IA, OK	North Star Horizon
Data Analysis	Interactive analysis of procedure results	Bolt Beranek and Newman (BBN) Boston, MA	DEC 10 Tenex
Control of Printer Device	Continual communications with BBN and PDP for improving printer efficiency	In-house Washington, D.C.	North Star Horizon
Landsat Scene Classification,	Computationally intensive data analysis functions	NASA-Ames Research Center	Cray X-MP
Data Clustering		Moffett Field, CA	

Appendix B

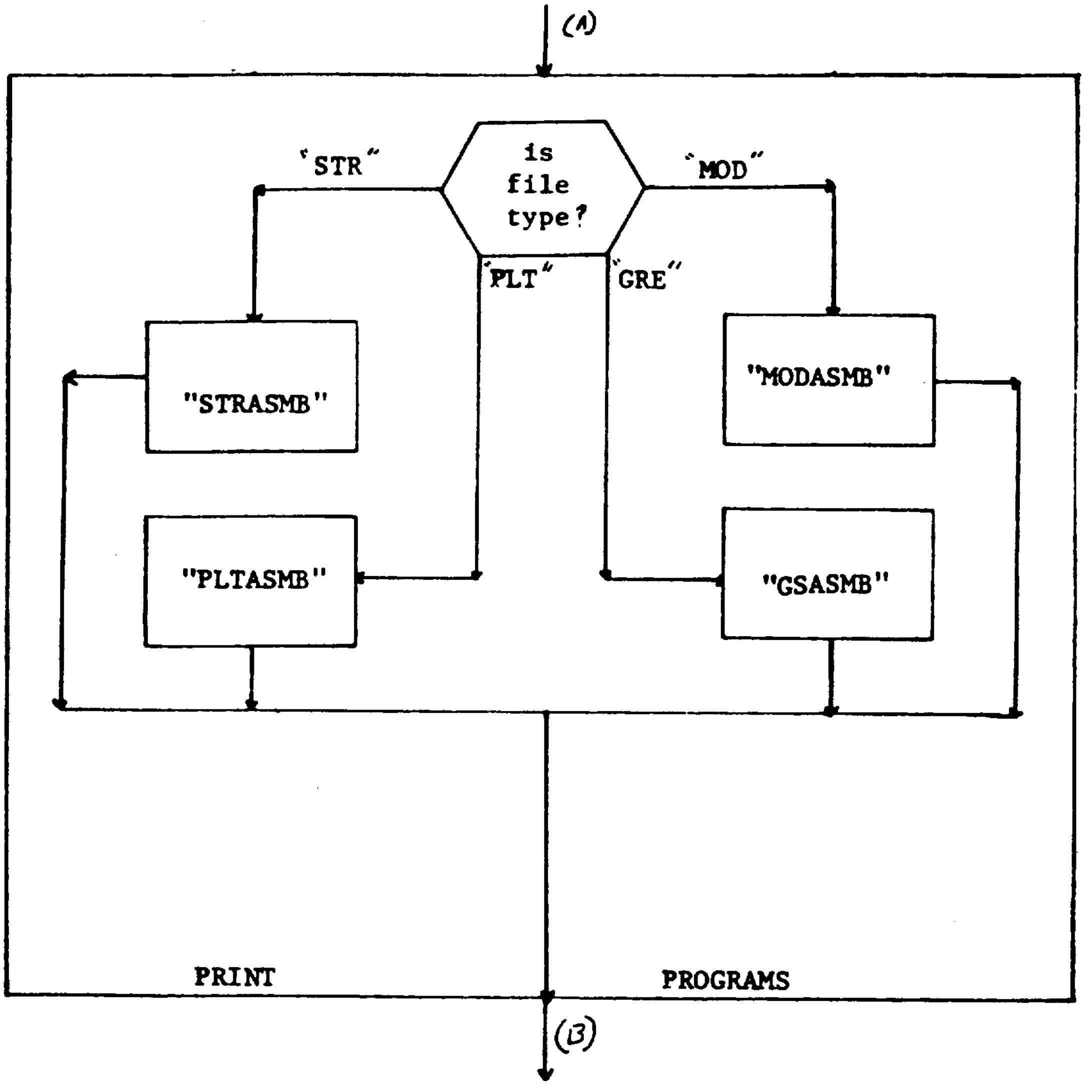
North Star Horizon (Device Driver)

Processor	-	280 A
Memory	-	64 K
Disk	-	two Double Density, Single Sided 5-1/4" Floppy
Ports	-	two RS232 Serial one parallel input one parallel output three additional RS232 on 5100 board
Terminal	-	one ADM-3
Operating System	-	North Star DOS

Appendix C.1
North Star Print Driver Program
Flow Chart



Appendix C.2
North Star Print Driver Program
Flow Chart Cont.



Appendix D

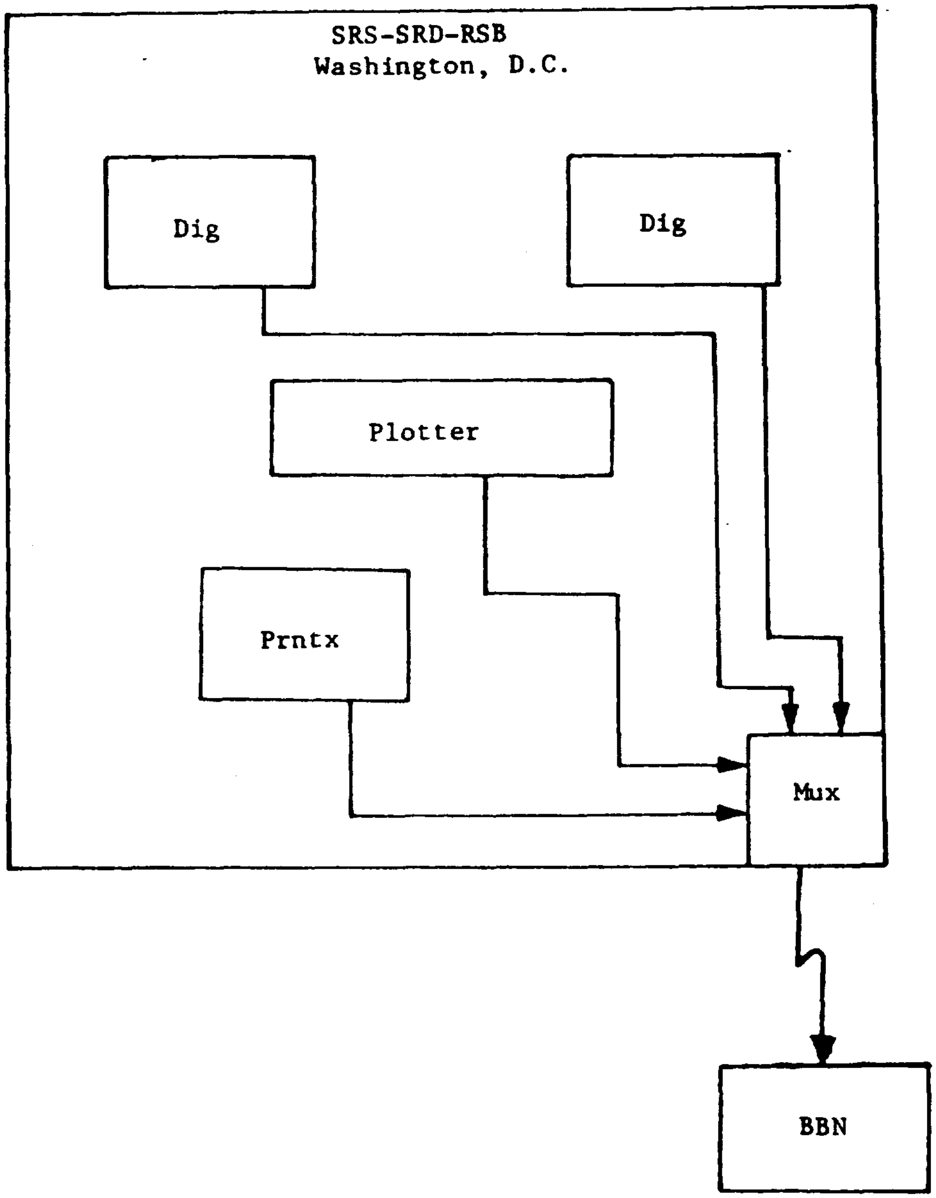
North Star Horizon (Digitizing Work Station)

Processor	-	280 A
Memory	-	64 K
Disk	-	two Double Density, Double Sided 5-1/4" Floppy
Ports	-	two RS232 Serial one parallel input one parallel output
Terminal	-	one Televideo 912
Modem	-	one Racal-Vadic VA 3451
Operating System	-	CP/M

Costs as of October 25, 1982

North Star Horizon	$ 3,599
Televideo Terminal	$ 903
Cables	$ 35
Diskettes	$ 45
Modem	$ 650
	$ 5,187

Figure -1-
RSB's Original Processing System
Configuration



Dig- Altec Digitizing Station

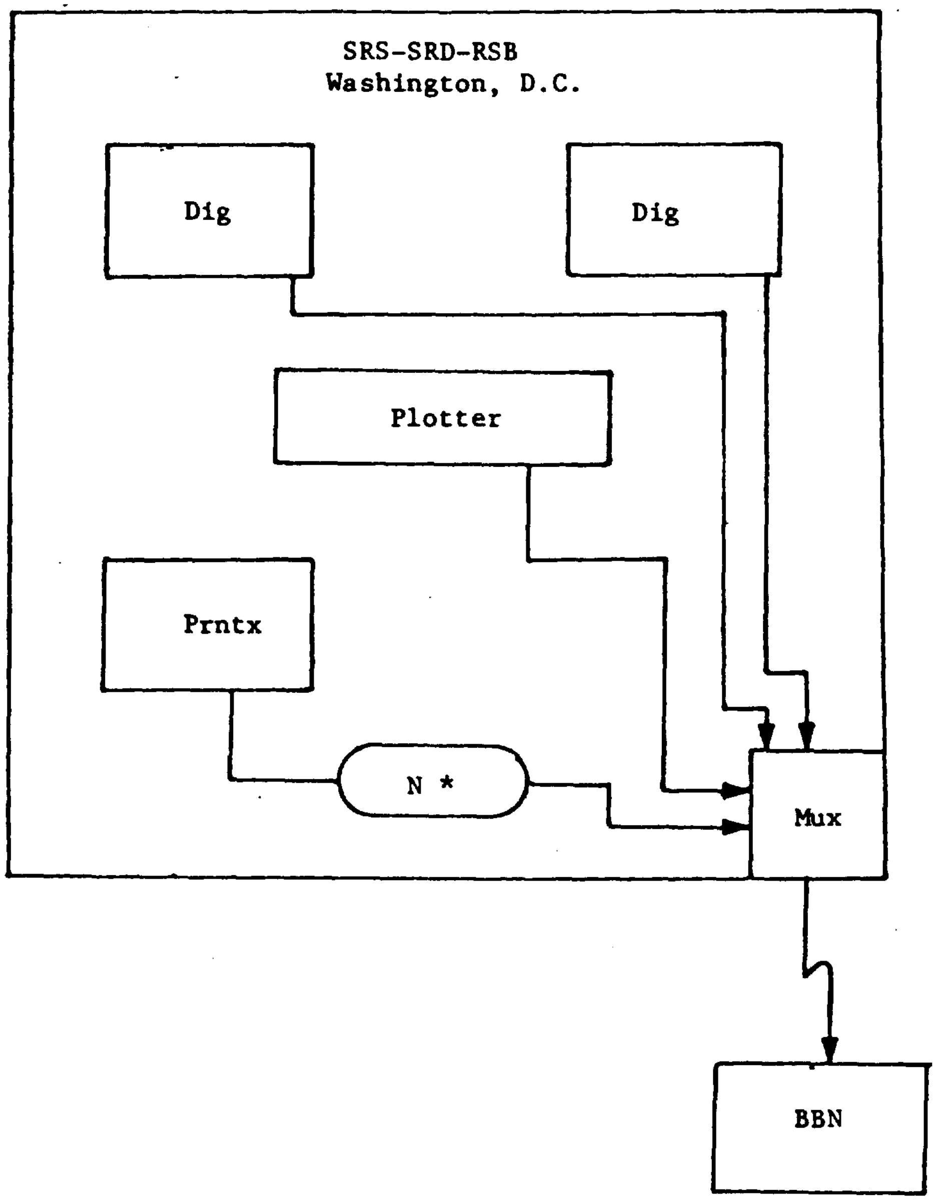
Plotter- Houston Instruments Complot Plotter

Prntx- Printronix/Trilog Color Printer

Mux- Codex 910 Time sharing Multiplexer

BBN- Bolt, Beranek and Newman, Boston, MA

Figure -2-
RSB's First Stage Integration
Configuration



Dig- Altec Digitizing Station

Plotter- Houston Instruments Complot Plotter

Prntx- Printronix/Trilog Color Printer

Mux- Codex 910 Time sharing Multiplexer

BBN- Bolt,Beranek and Newman, Boston, MA

N *- North Star Horizon

Figure -3-
Typical RSB Greyscale Print

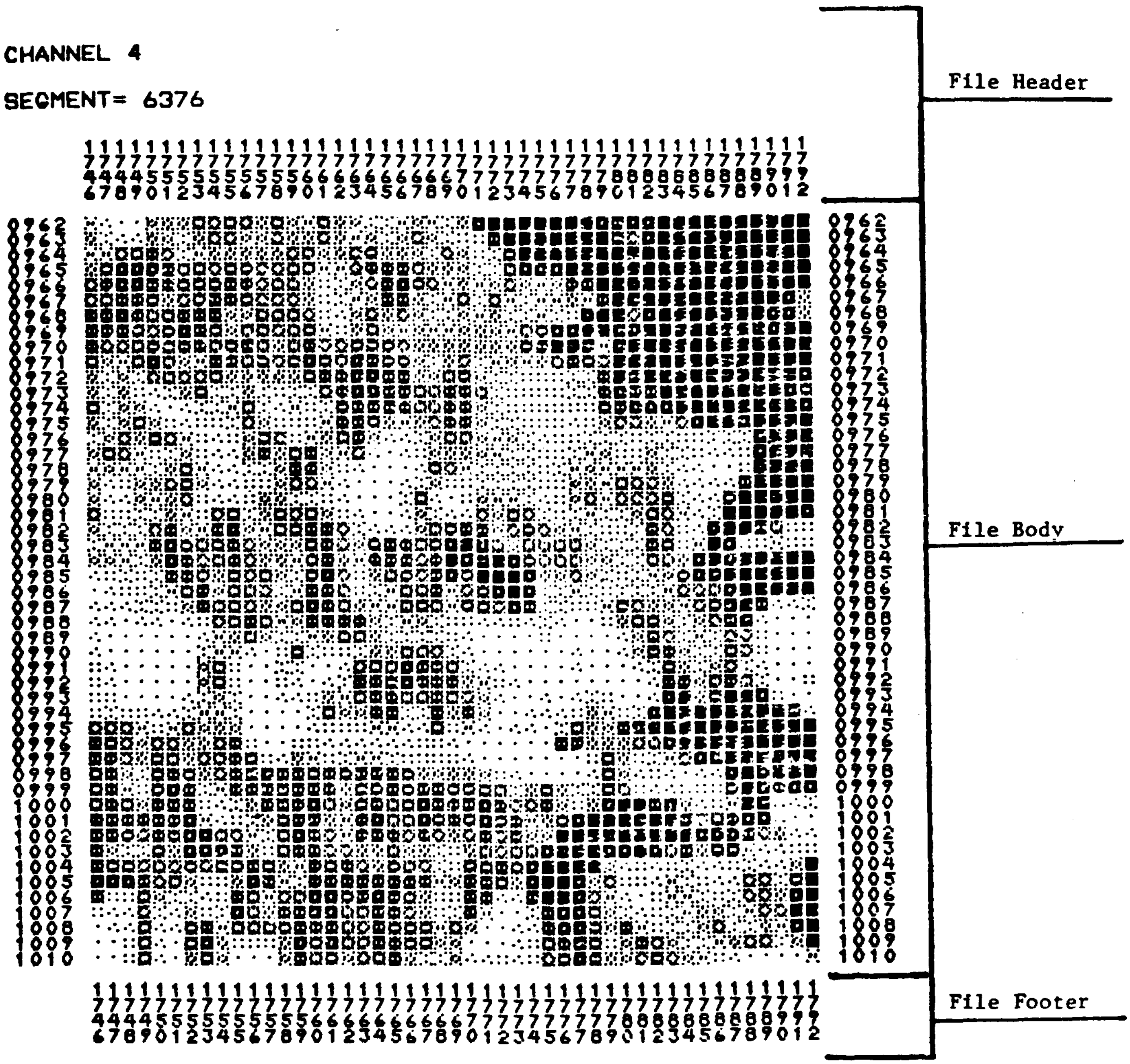
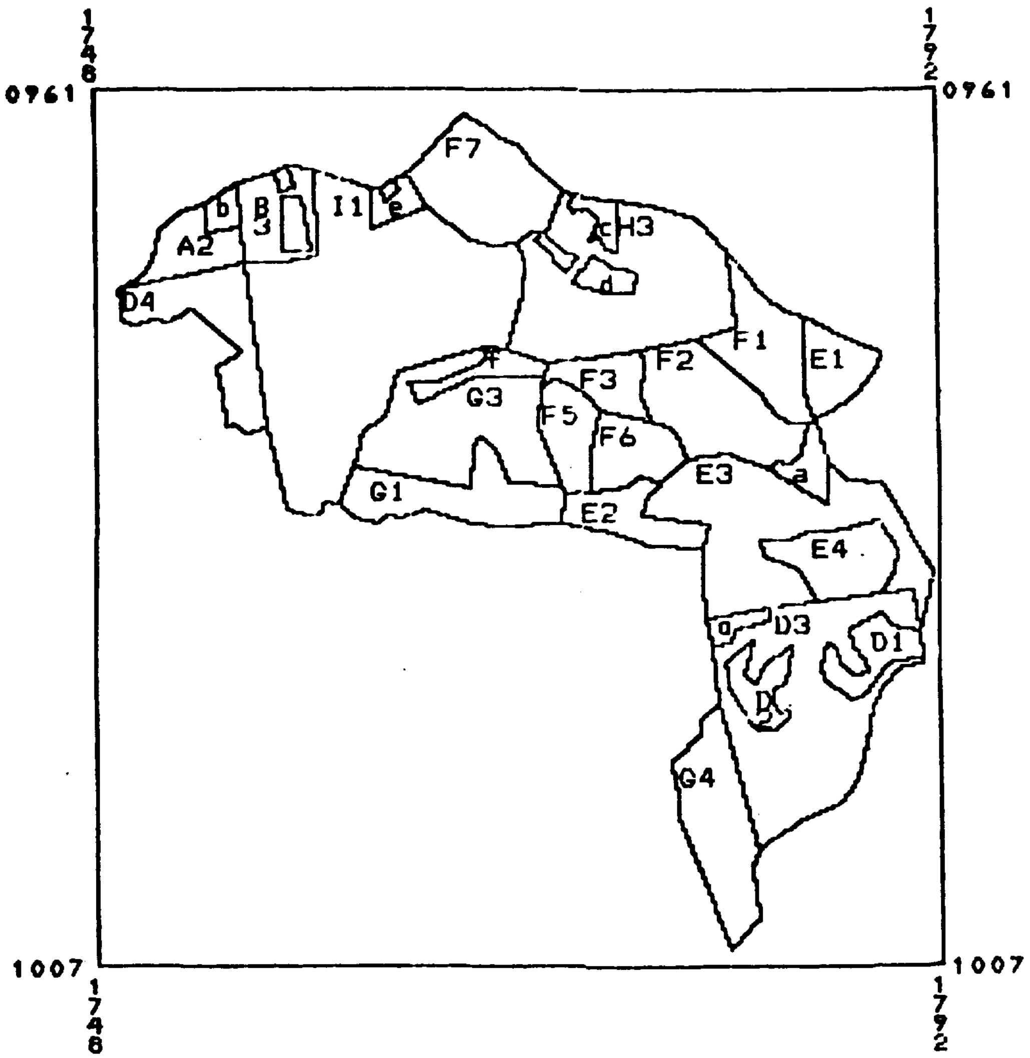


Figure -4-
Typical RSB Landsat Plot



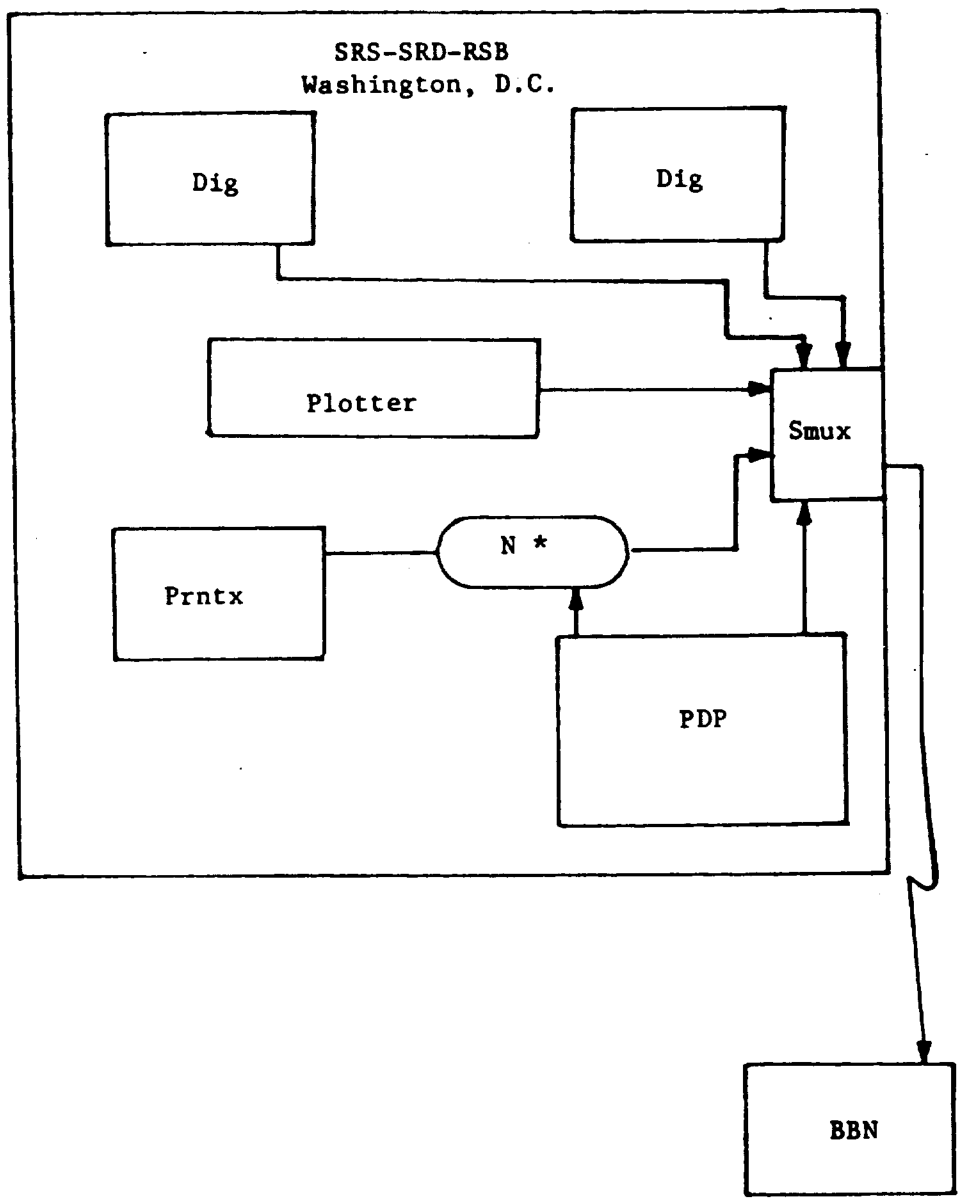
File Body

SEGMENT 6376 PART 1 OF 1 FROM MO83
SEGMENT NETWORK FILE=(MO-DIG2)6376.SEG/MO83;2
CALIBRATION FILE=(MO83)40293-16060.PCAL-3/MO83;1

KEYED FIELD NAMES
a=F4 b=A1 c=J1 d=H2 e=C2 f=G2 g=D5
THE FOLLOWING FIELDS COULD NOT BE LABELLED:
B1 B2 C1 H1

File Footer

Figure -5-
RSB's Current Processing System
Configuration



Dig- Altec Digitizing Station

Plotter- Houston Instruments Complot Plotter

Prntx- Printronix/Trilog Color Printer

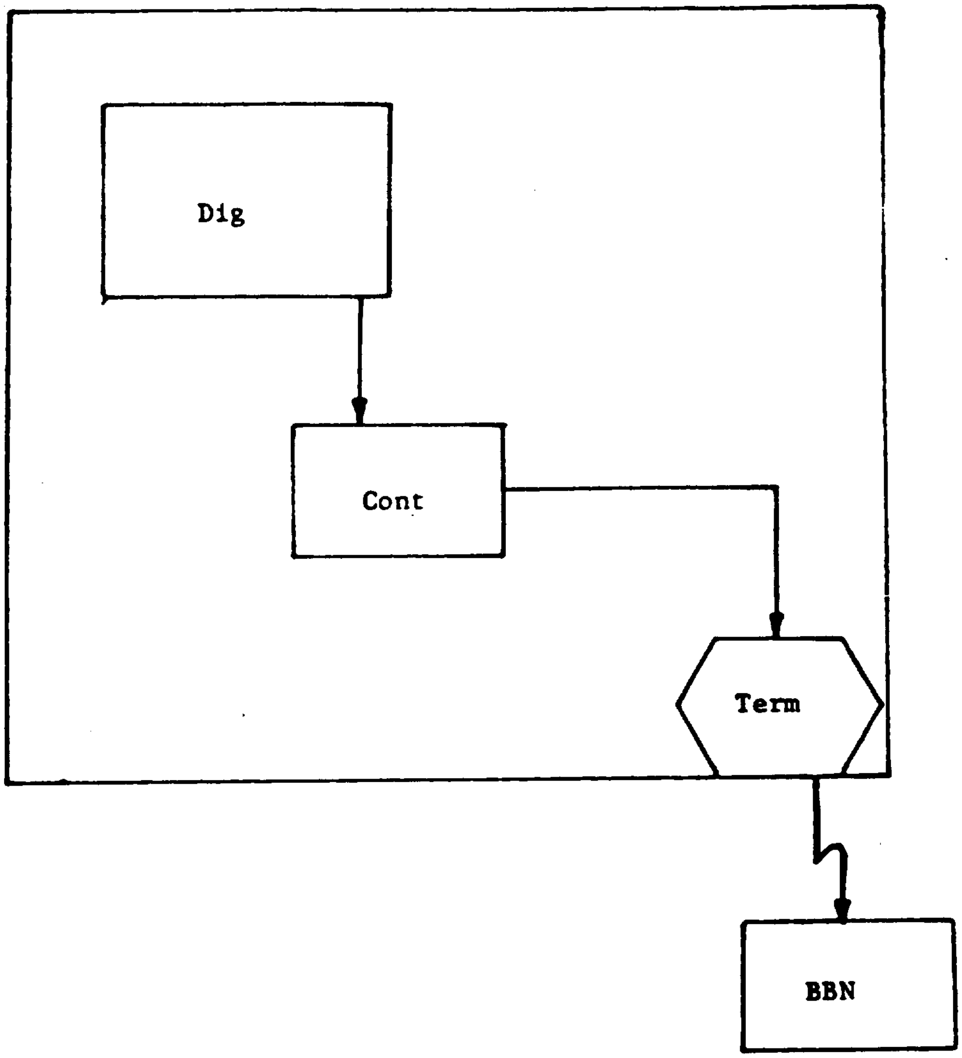
BBN- Bolt, Beranek and Newman, Boston, MA

N *- North Star Horizon

PDP- DEC PDP 11/44 Minicomputer

Smux- Codex 6010 Statistical Multiplexer

Figure -6-
Field Office Digitizing Station
Original Configuration



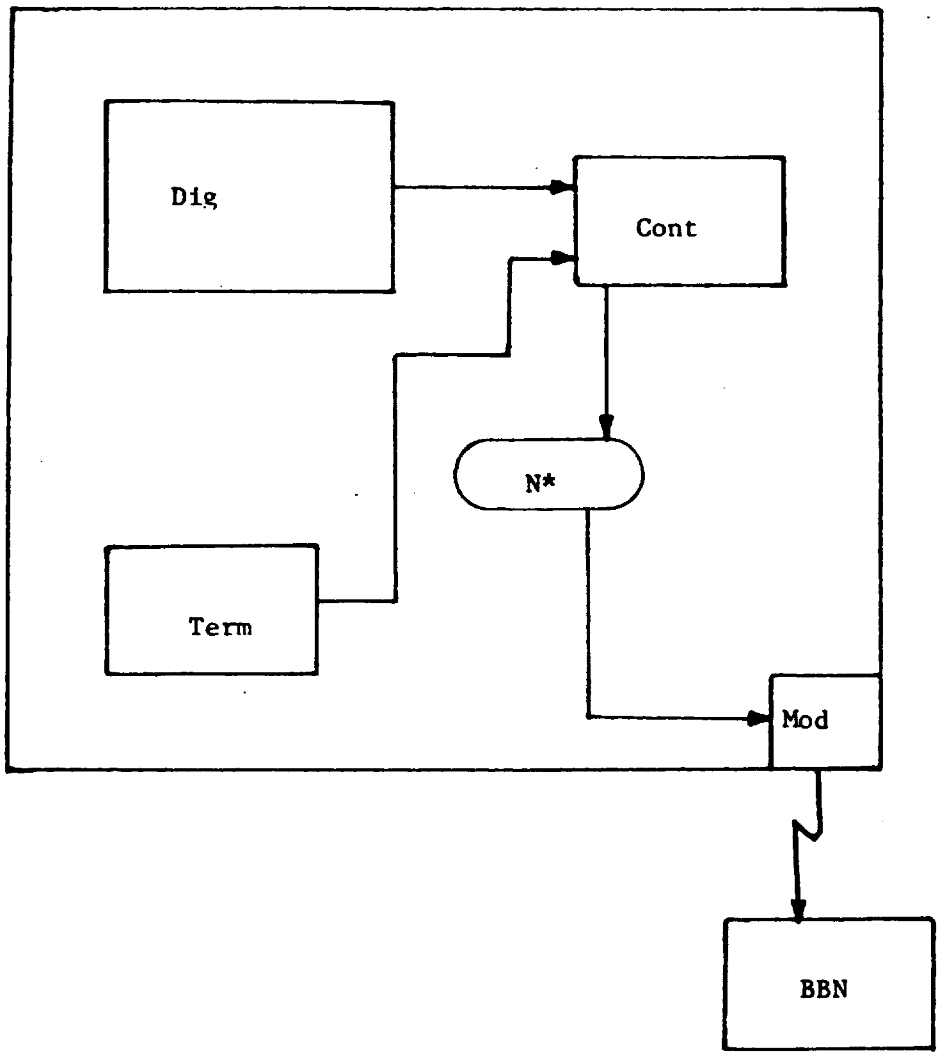
Dig - Altec Digitizing Tablet

Cont - Altec AC90 Digitizing Controller

Term - Computer Devices 1030 Terminal
(used as a terminal and modem)

BBN - Bolt, Beranek and Newman, Boston, MA

Figure -7-
Field Office Digitizing Station
Current Configuration



Dig - Altec Digitizing Tablet

Cont - Altec AC90 Digitizing Controller

Term - Televideo 912 Terminal

N* - North Star Horizon

Mod - Racal-Vadic VA3451 Modem

BBN - Bolt, Beranek and Newman, Boston, MA